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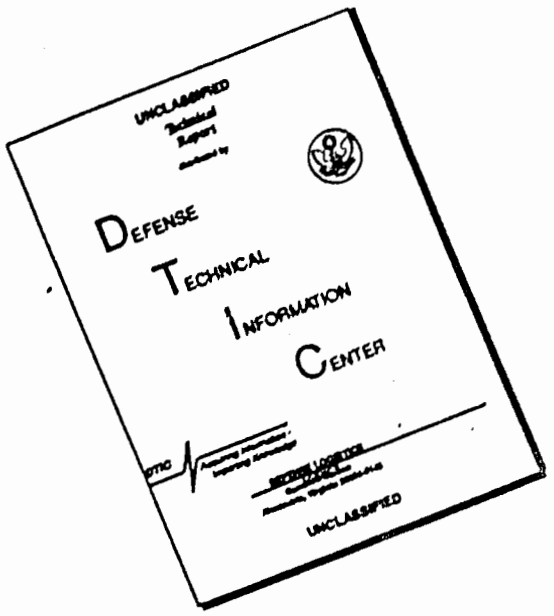

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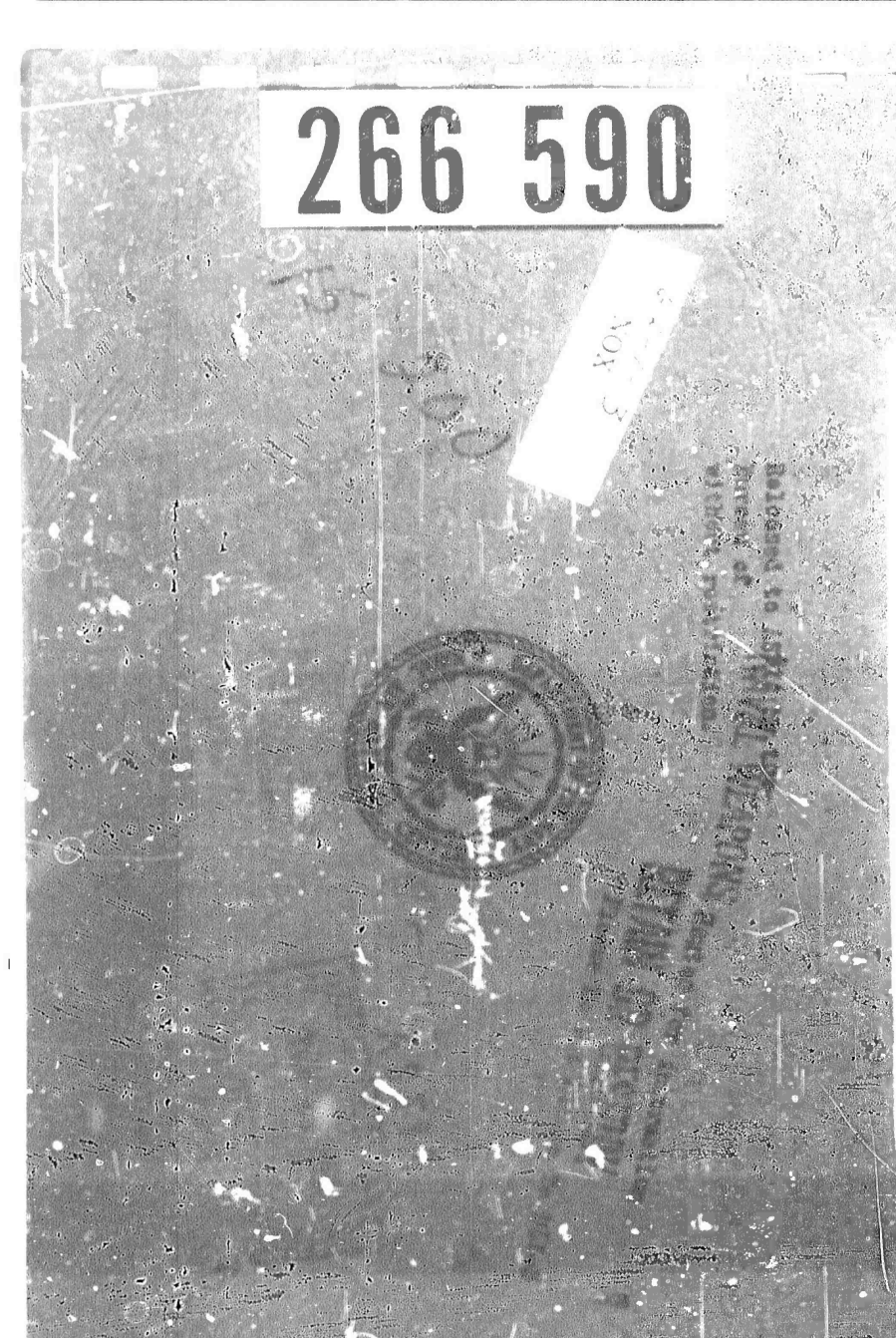

NOTICE

NAVAL AIR MATERIAL CENTER
PHILADELPHIA 12, PENNSYLVANIA

AERONAUTICAL MATERIALS LABORATORY

REPORT NO. NAMC-AML-1291 DATE 25 September 1961

A STUDY OF THE SHORT TIME ELEVATED TEMPERATURE PROPERTIES OF CIAD X2020-T6 AND 7075-T6 ALUMINUM ALLOY SHEET

PROBLEM ASSIGNMENT NO. C 10 RMA 21-10
(FORMERLY AE 41117 - MA 2028) UNDER BUREAU OF
NAVAL WEAPONS WEPTASK RRMA 02 018/200 1/ROO 05 002

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ABSTRACT

Short exposure time tensile tests were performed on clad 7075-T6 and clad X2020-T6 aluminum sheet. The exposure temperatures used were 300°F, 350°F, 400°F, 450°F, and 500°F. The exposure times were 3, 10, 30, 60, and 600 seconds. Specimens were tested at temperature and at room temperature after exposure. The strain rates used were 0.002 and 0.054 inches per inch per minute.

I. INTRODUCTION

A. This investigation was conducted to obtain data for use in establishing the effect of nuclear ... ons blasts on aircraft skin materials. The environment produced by such blasts is rapid radiant heating followed by shock wave loading. The obvious need was for tensile data after rapid heating and short exposures. Data of this type is limited since for most applications exposure times of 1/2 hour are the shortest reported. Therefore, reference (a) established this project for the purpose of obtaining the required short-time tensile data for clad aluminum alloys X2020-T6 and 7075-T6.

B. The work done under reference (a) was divided into two parts. The first part consisted of the investigation and development of methods for rapid and uniform heating of aluminum alloy specimens by the use of programmed high-intensity quartz heat lamps. In addition, techniques for measuring the load imposed on the specimen and the specimen elongation under load during rapid loading were developed. This work was performed by the Aeronautical Structures Laboratory (ASL), Naval Air Material Center, Philadelphia, Pa., and is reported in reference (b). The second part of the work consisted of the collection and analysis of short exposure time tensile data and is reported herein.

II. SUMMARY OF RESULTS

A. The data obtained from tensile tests of specimens exposed to elevated temperatures for short times (3 to 600 seconds) are shown in Plates 1 to 12 inclusive and Table 1.

B. In general the changes in tensile strength properties observed during this investigation were those which are to be expected in an age-hardened material.

C. Specimens exposed to several thermal pulses in general have the same strength properties (Plate 13) as specimens exposed to a single pulse equal to the sum of the times of the several pulses.

III. CONCLUSIONS

A. In the alloys studied the observed results were those which are to be expected in an age-hardening material; that is, a slight increase in strength properties after short exposures followed by a decline in these properties on longer exposure.

B. For all comparable conditions the clad X2020-T6 aluminum alloy exhibited ultimate tensile and yield strengths superior to those for clad 7075-T6 aluminum alloy.

IV. RECOMMENDATIONS

A. It is recommended that the data obtained in this investigation be used where the design criteria is short time tensile strength for elevated temperature applications.

TABLE OF CONTENTS

LIST OF TABLES AND PLATES

TABLES

PLATES

PLATES (Continued)

V. TEST CONDITIONS

A. Three series of tensile tests were conducted. In the first series, the specimens were exposed to various temperatures in molten salt before testing at room temperature at a normal strain rate (0.002 in./in./min.). The two remaining series were exposed to the various temperatures via radiant heat lamps for the required times. One of the latter series was tested at the end of the exposure period at a fast strain rate (0.054 in./in./min.). The other series was cooled to room temperature then tested at the fast strain rate.

B. In all cases triplicate tests were run and an average result is reported. The two types of specimens used in these tests are shown in Plate 14. The thermocouples attached to the specimens heated by quartz lamps, were ultrasonically welded in place. The effects of the ultrasonic weld do not extend through the cladding of the materials used, as shown in Plate 15. Therefore, no adverse effects were expected and none were observed.

C. The specimens exposed in molten salt were clad 0.040 inch 7075-T6 alloy and clad 0.063 inch X2020-T6 alloy. Before the specimens were dipped the bath was stirred and the temperature read by means of a thermocouple and a portable potentiometer. The times necessary for the specimens to reach temperature were found using a thermocouple attached to a specimen and a high speed recording potentiometer. The specimens were then exposed for times at temperature of 3 sec., 10 sec., 30 sec., 60 sec., and 10 minutes. The exposure temperatures used were 300°F, 350°F, 400°F, 450°F, and 500°F. After exposure, the specimens were tensile tested at room temperature at a strain rate of 0.002 inches per inch per minute. Ultimate tensile strength, 0.2% yield strength, and total elongation in 2 inches were calculated and recorded.

D. The materials used in the radiant heat lamp series were 0.063 inch clad X2020-T6 and 7075-T6. A complete description of the equipment and techniques used in these tests may be found in reference (b). The specimens were held at temperature 3 sec., 10 sec., 30 sec., 60 sec., and 10 minutes. Tables 2 and 3 give indications of the accuracy of temperature control and of temperature distribution along the specimen. They were then tested immediately or cooled to room temperature for testing. The exposure temperatures used were 300°F, 350°F, 400°F, 450°F, and 500°F. The strain rate used for these tests was 0.054 in./in./min. Ultimate tensile strength and 0.2% yield strength were calculated from the data obtained.

E. To simulate the effect of nuclear blast on clad 7075-T6 aluminum alloy several specimens were exposed to radiant heat pulses of three seconds duration at either 300°F or 400°F. Specimens were exposed to 1, 2, 4, and 8 pulses. After each pulse (except the final one) the specimen was cooled to ambient temperature. After the final pulse the specimens were tensile tested at temperature at a strain rate of 0.054 inch per inch per minute.

VI. ANALYSIS OF TEST RESULTS

A. The results of the short time at temperature exposure tensile tests performed during this investigation are shown in Plates 1 to 12. For comparison purposes data normally obtained from the as-received material at room temperature are included in the plates. In a significant portion of the data, the maximum tensile values occur after exposures of 10 to 30 seconds. Note should be taken of the fact that this effect was observed both in specimens exposed in salt and those exposed to radiant heat. Therefore, the effect seems to be due to the heating alone and not to the method of heating or strain rate. Thus, the apparent cause of the maximums would be a continuation of the age-hardening reaction.

B. Except for these maximum points discussed above, the material behaves as would be expected. That is, as the exposure time at temperature and the temperatures are increased, the tensile strength properties decrease.

C. Plate 13 shows the data obtained from specimens exposed to thermal pulses. Comparison of this data with the data given in Plates 5 and 6 show that the tensile values are approximately the same for a given total exposure.

REFERENCES

(a) BUAER ltr Aer-AE-415/223 of 12 Nov 1959

(b) Report No. NAMC-ASL-1040

ELONGATION OF CLAD 7075-T6 AND X2020-T6 ALUMINUM SHEET TESTED AT ROOM TEMPERATURE AFTER EXPOSURE IN MOLTEN SALT
STRAIN RATE 0.002 "/" MINUTE

Exposure Temperature	Exposure Time, Sec.	7075-T6 Elongation in 2 inches, %	X2020-T6 Elongation in 2 inches, %
300°F	3	---	7
	10	---	6
	30	11	---
	60	12	---
	600	12	---
350°F	3	11	7
	10	11	7
	30	12	6
	60	12	6
	600	11	6
400°F	3	12	7
	10	13	6
	30	11	6
	60	10	6
	600	10	6
450°F	3	11	7
	10	12	7
	30	11	6
	60	10	6
	600	11	7
500°F	3	9	8
	10	9	8
	30	11	7
	60	10	6
	600	11	7

TABLE 1

TABLE 2

TEMPERATURES AT THE END OF EXPOSURE TIMES

Temperature Programme	Specimen Designation Number	Thermocouple Number and Location	Exposure Time and Specimen Temperature				
			3 Sec.	10 Sec.	30 Sec.	60 Sec.	10 Min.
	109	No. 3 - Center	308				
	135	" "	308	299			
300°F	31	" "	305	315	305		
	136	" "		302	295	295	
	103	" "				299	299
	26	" "	353				
	25	" "	363	351			
350°F	22	" "	351	360	351		
	17	" "		370	360	351	
	19	" "		370	357	351	351
	52	" "	402				
	53	" "	412	399			
400°F	56	" "		412	402		
	57	" "		412	409	402	
	302	" "			412	400	400
	48	" "	451				
	35	" "	467	451			
450°F	38	" "	448	457	451		
	41	" "		463	454	448	
	44	" "			460	451	448
	304	" "	500				
	312	" "	512	506			
500°F	140	" "	484	496	493		
	108	" "		485	484	485	
	101	" "				512	497

UNIFORMITY OF TEMPERATURE IN SPECIMENS

Specimen A								
	Test 1		Test 2		Test 3		Test 4	
T/C No.	3 Sec.	6 Sec.	3 Sec.	6 Sec.	3 Sec.	6 Sec.	3 Sec.	6 Sec.
Top 1	Programmed for 350°F							
Center 3	347	367	347	367	347	367	347	367
Bottom 4	385	341	385	344	385	341	389	341

Specimen B										
	Test 1		Test 2		Test 3		Test 4		Test 5	
T/C No.	3 Sec.	6 Sec.	3 Sec.	6 Sec.	3 Sec.	6 Sec.	3 Sec.	6 Sec.	3 Sec.	6 Sec.
Top 1	Programmed for 350°F									
Center 3	347	370	370	376	370	376	373	380	373	380
Bottom 4	366	328	367	331	373	334	376	334	373	334

TABLE 3

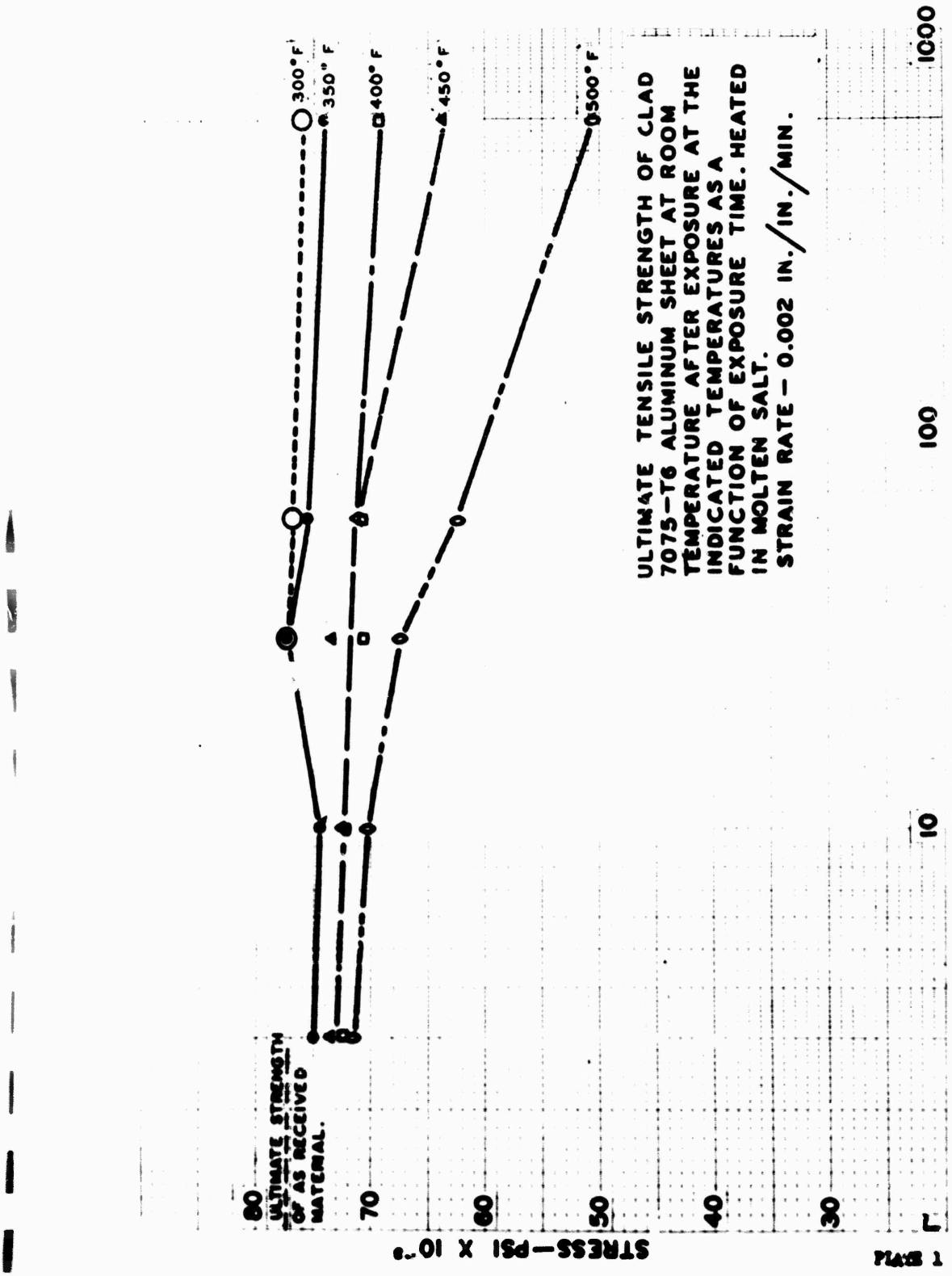

PLATE 1

PHOTO NO: CAN-339342(L)-9-61

PLATE 1

PHOTO NO: CAN-339343(L)-9-61

PLATE 2

PLATE 3

PHOTO NO: CAN-339344(L)-9-61

PLATE 3

PHOTO NO: CAN-339345(L)-9-61

PLATE 4

PHOTO NO: CAN-332346(L)-9-61

PLATE 8

PHOTO NO: CAN-339347(L)-9-61

PLATE 6

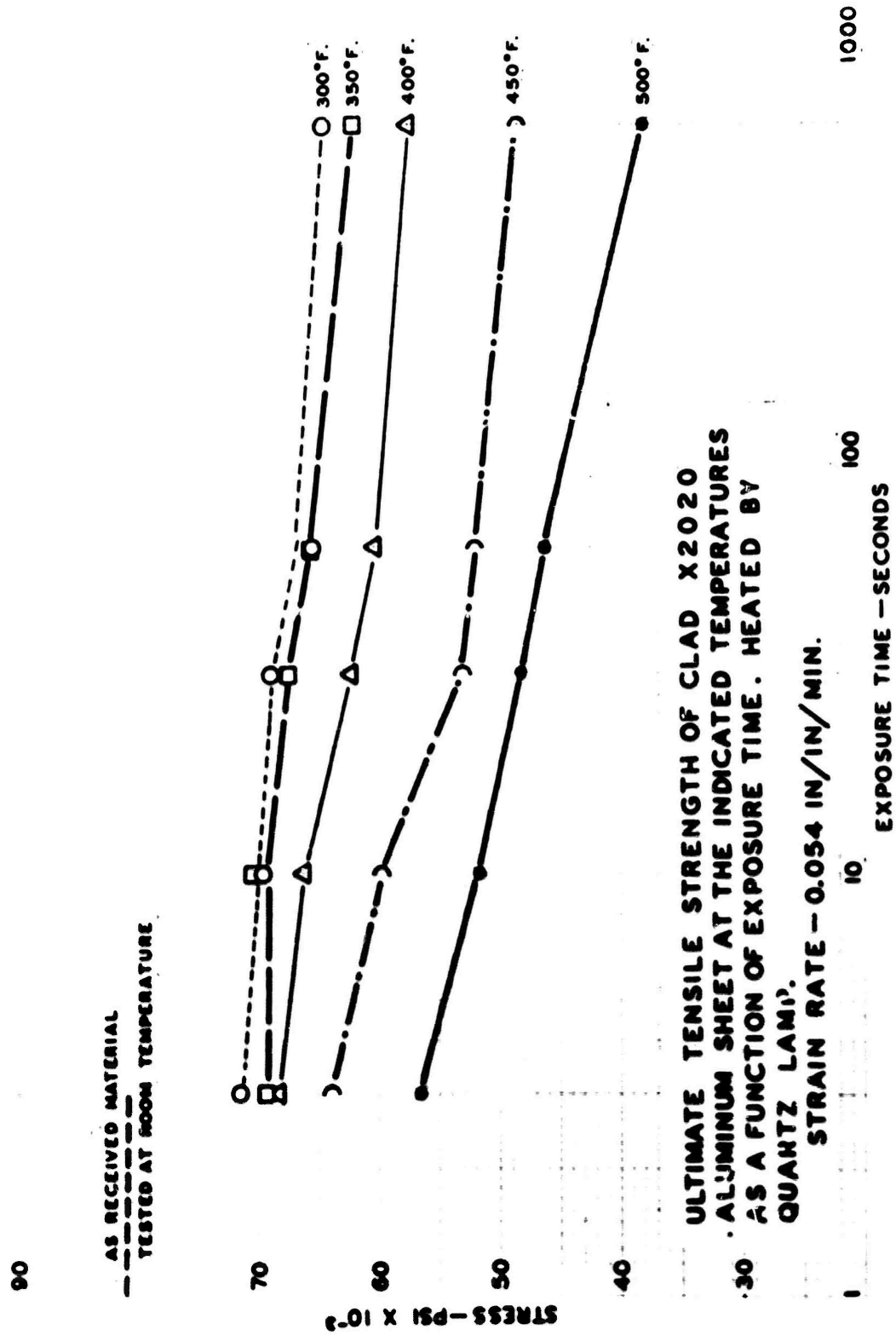

PHOTO NO: CAN-339348(L) 9-61

PLATE 7

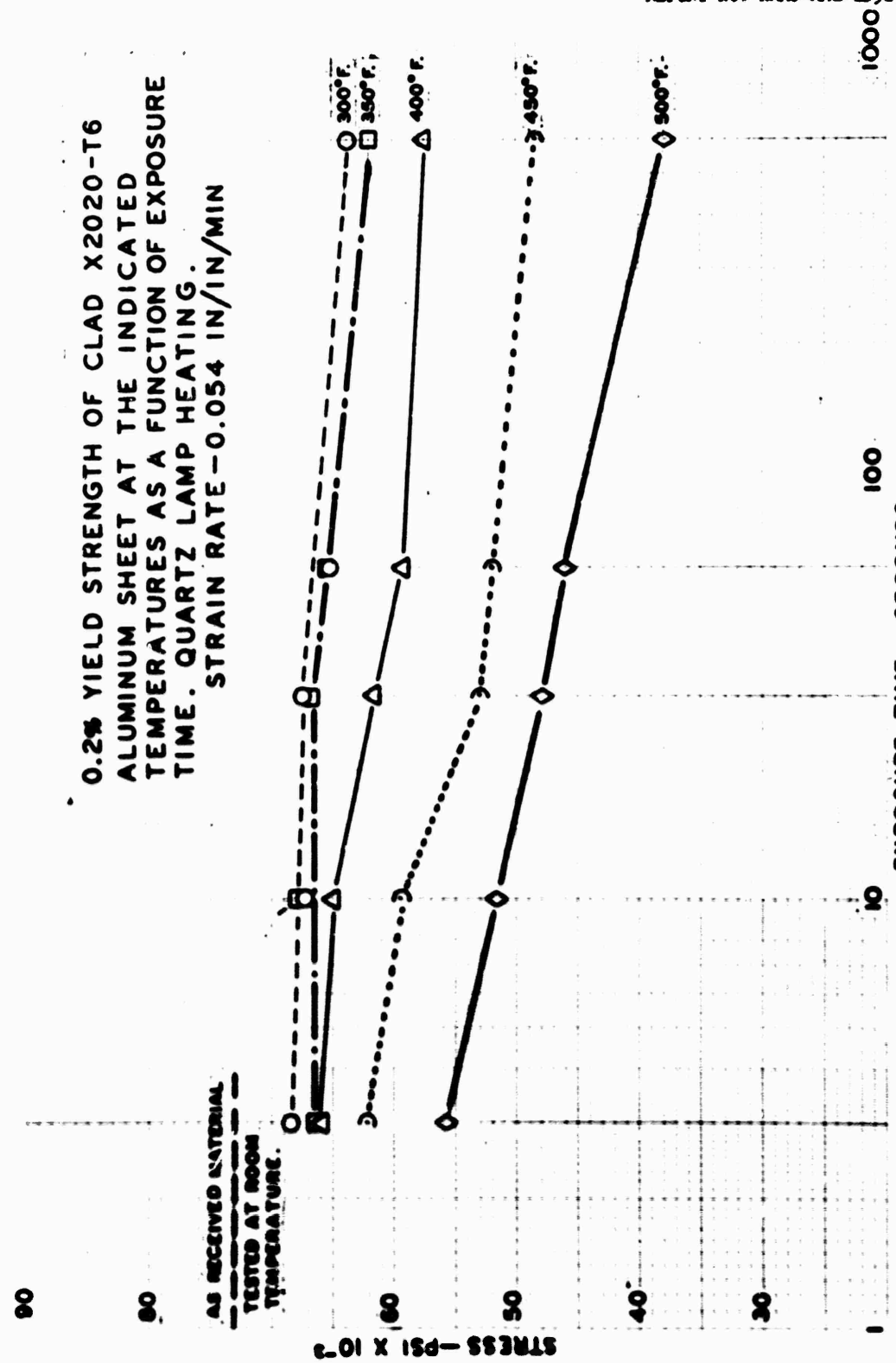

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PLATE 8

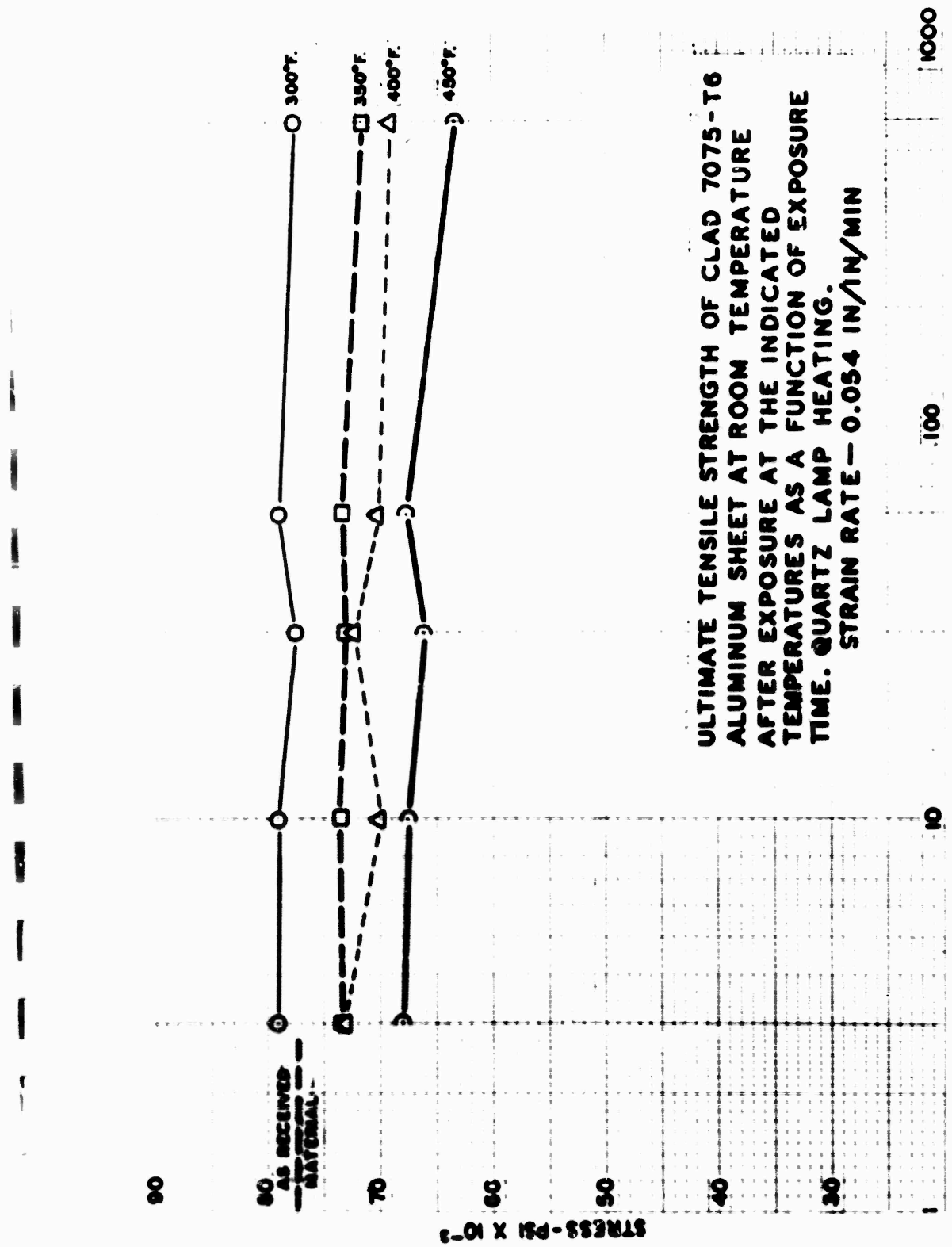

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PLATE 9

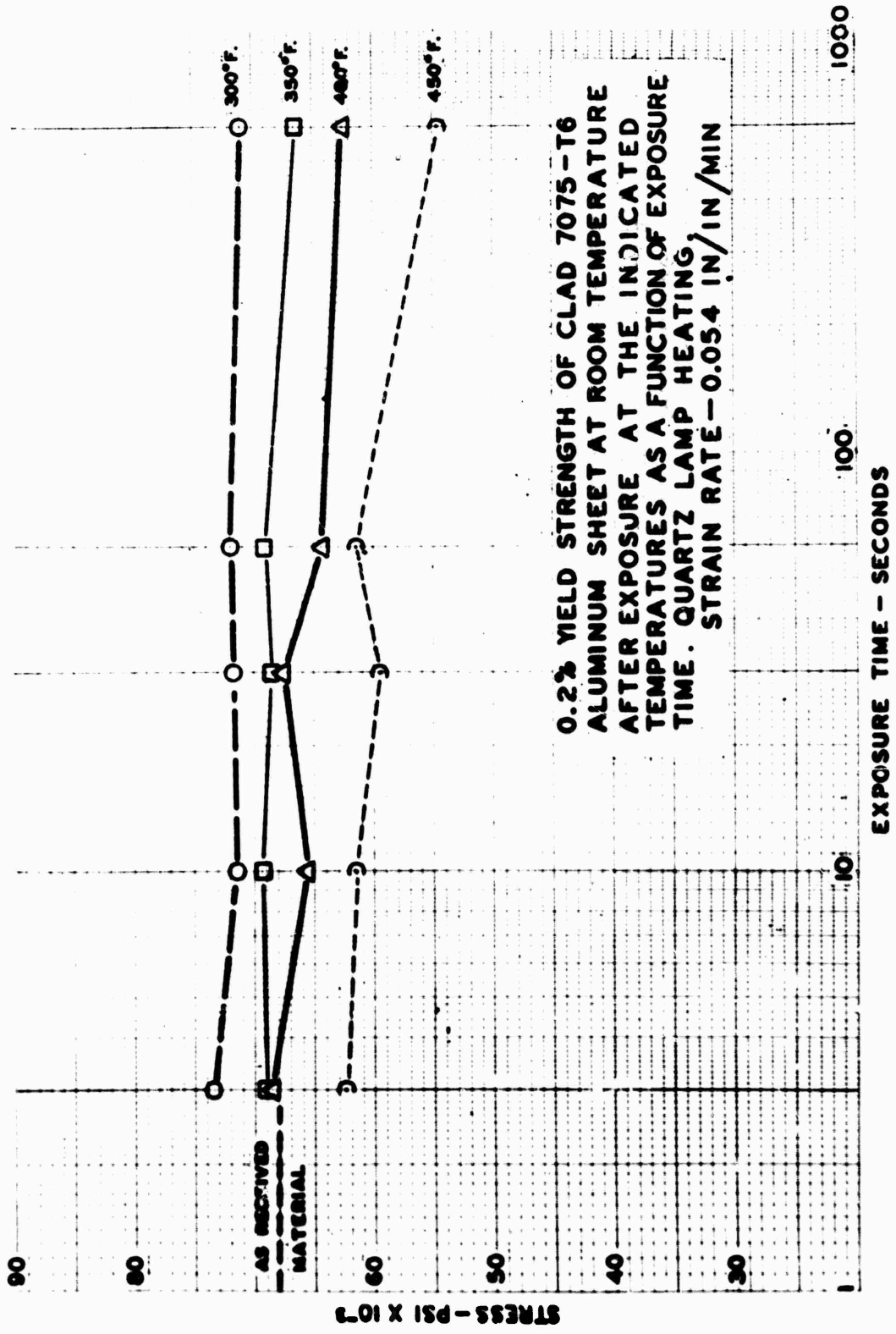

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PLATE 10

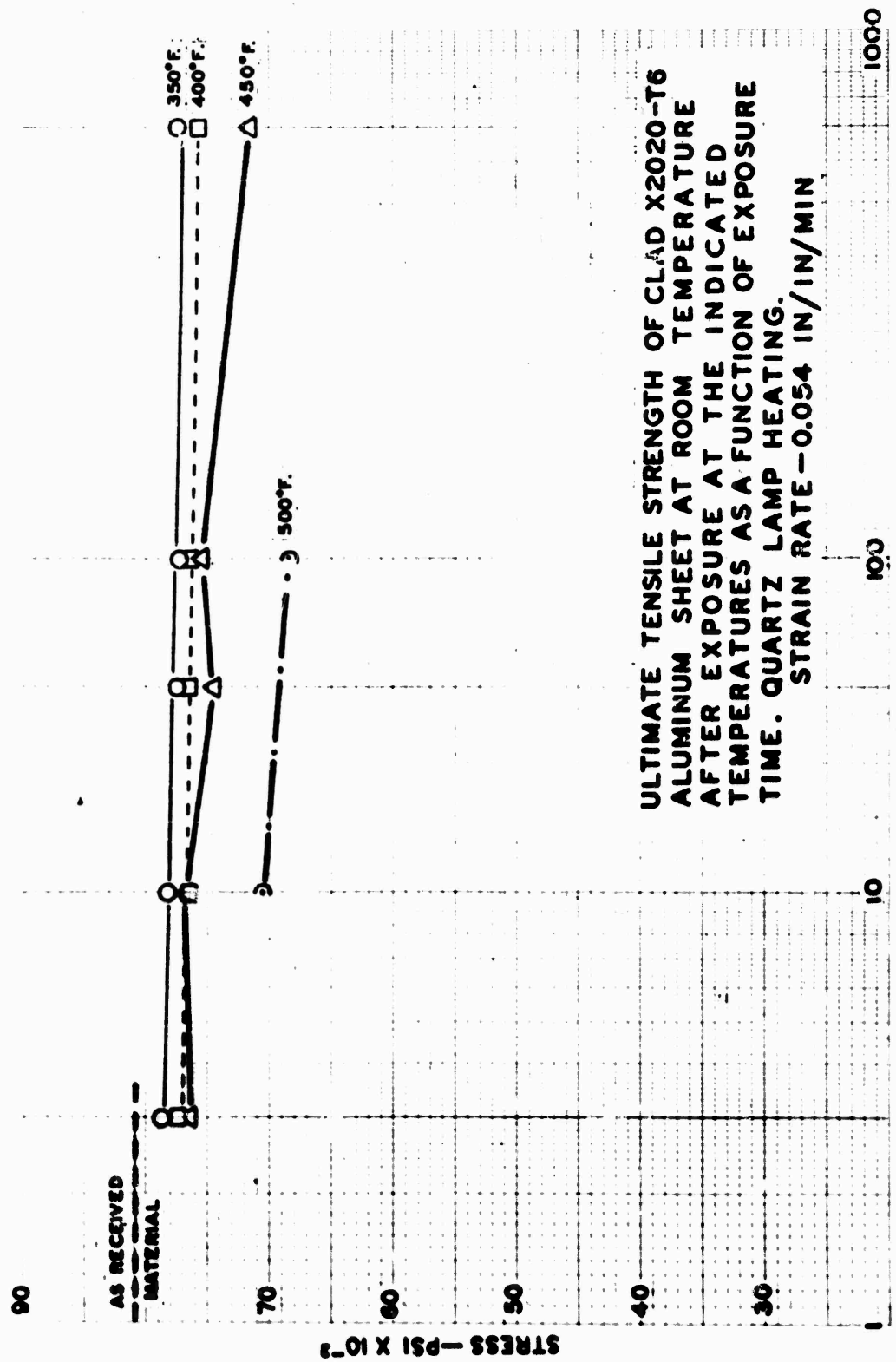

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PLATE 11

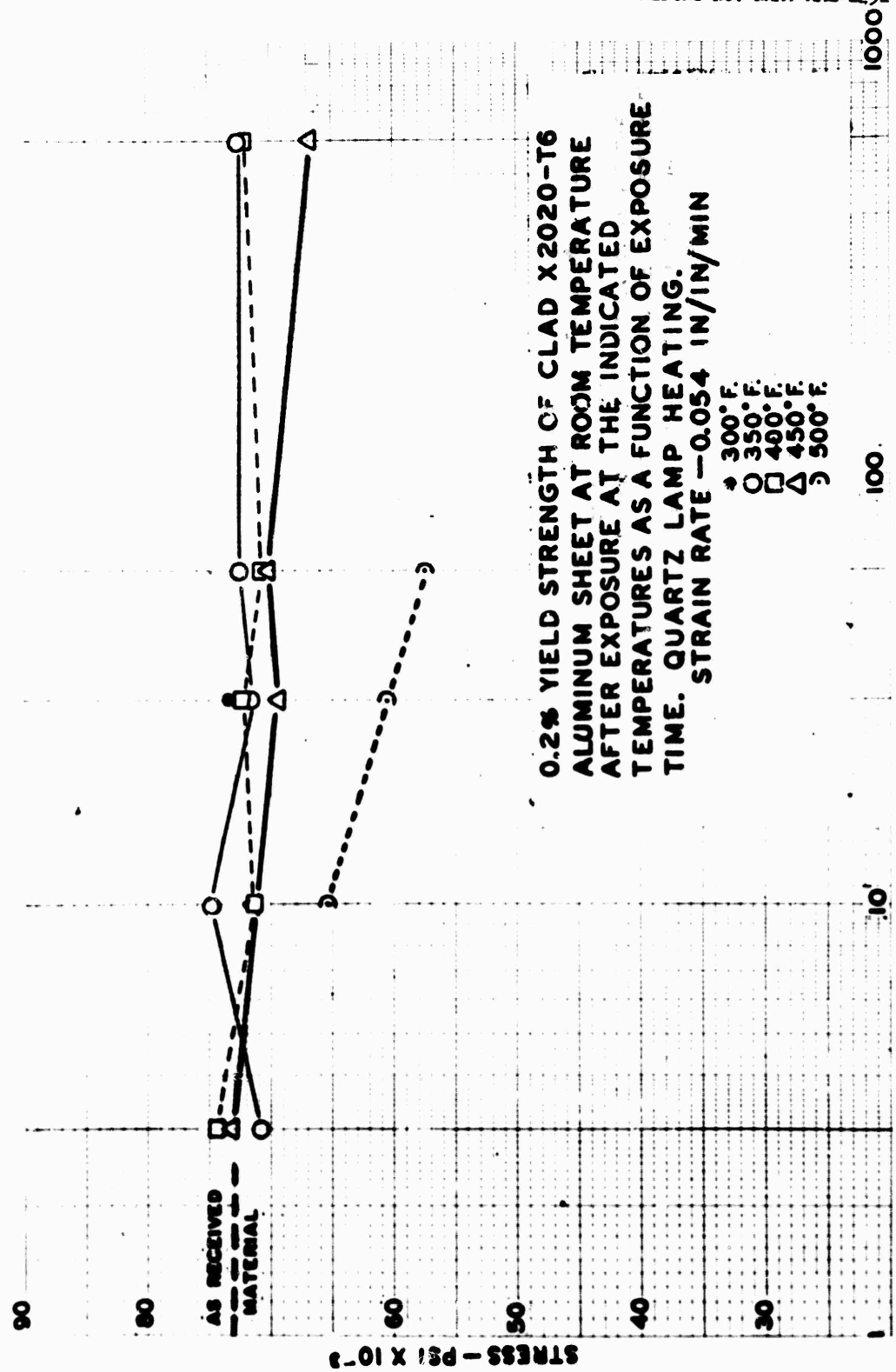
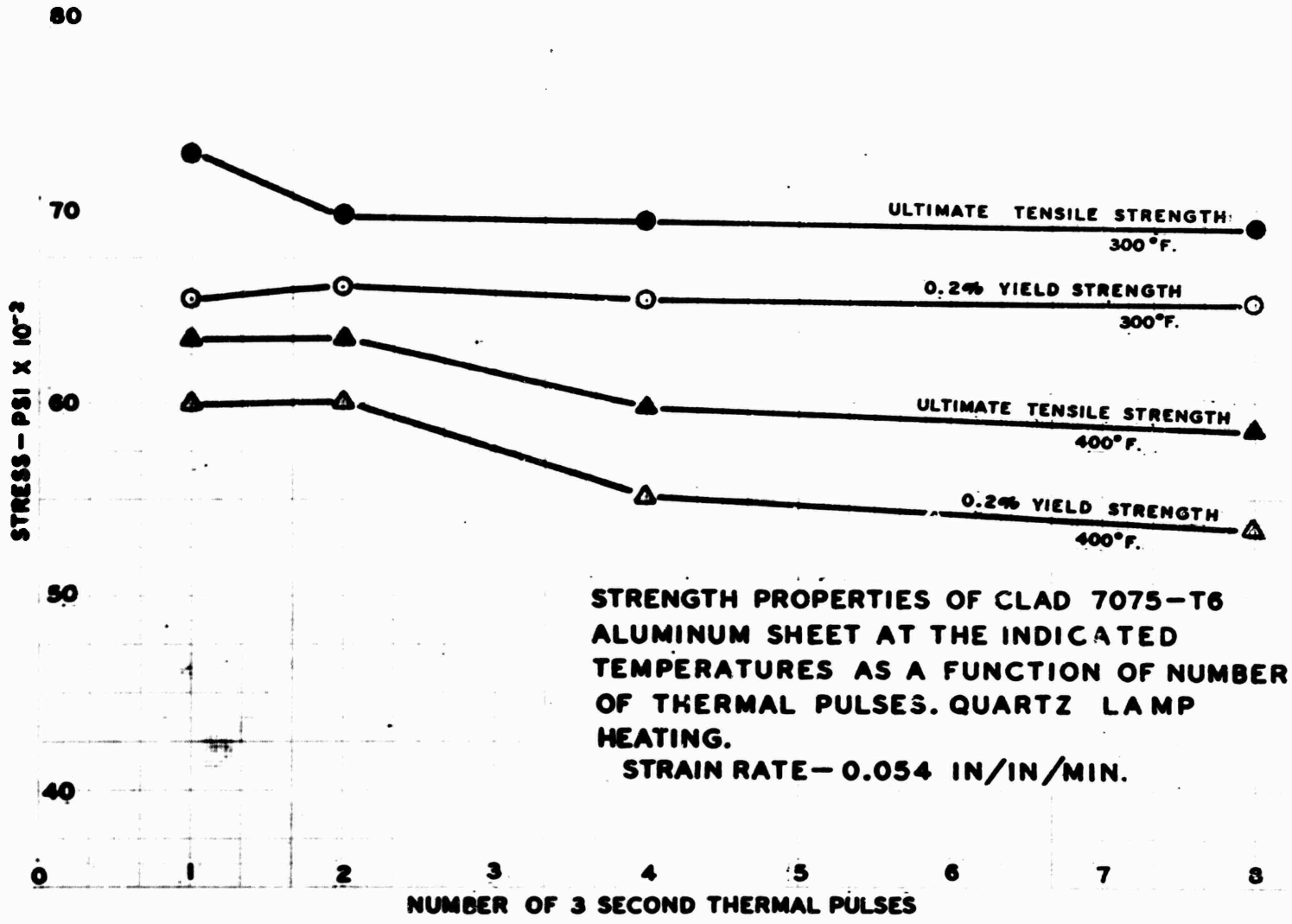


PHOTO NO: CAN-333353(L)-9-61

PLATE 12



STRENGTH PROPERTIES OF CLAD 7075–T6 ALUMINUM SHEET AT THE INDICATED TEMPERATURES AS A FUNCTION OF NUMBER OF THERMAL PULSES. QUARTZ LAMP HEATING.
STRAIN RATE – 0.054 IN/IN/MIN.

PHOTO NO: CAN-33954(L)-9-61

PLATE 13

REPORT NO. BAMC-AML-1291

PHOTOGRAPH OF TENSILE TEST SPECIMENS

Fig. 1 - Specimen used in molten salt exposure

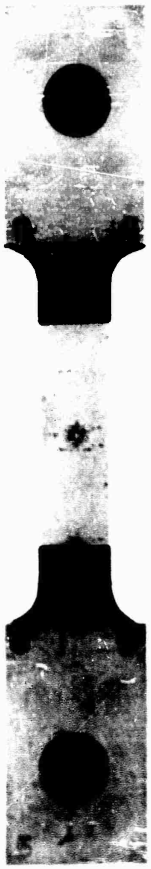
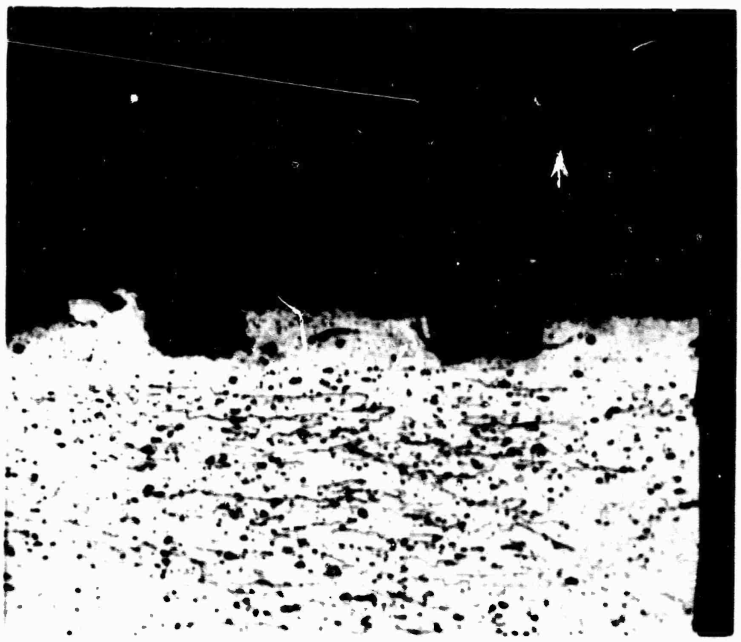


Fig. 2 - Specimen used in quartz lamp exposure

PHOTO NO: CAN-339355(L)-9-61

PLATE 14

PHOTOMICROGRAPH OF SECTION THROUGH AREA
OF ULTRASONIC WELD



MAG: 100X

Keller's Etch

PHOTO NO: CAN-339356(L)-9-61

PLATE 15

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1. REPORT NAMC-AML-1291
2. PAN C 10 RMA 21-10
(AE 41117-MA2028)

A Study of the Short Time Elevated Temperature Properties of Clad X2020-T6 and 7075-T6 Aluminum Alloy Sheet; by R. G. Mahorter, October 1961, 13 p., 15 Plates

Short exposure time tensile tests were performed on clad 7075-T6 and clad X2020-T6 aluminum sheet. The exposure temperatures used were 300°F, 350°F, 400°F, 450°F, and 500°F. The exposure times were 3, 10, 30, 60 and 600 seconds. Specimens were tested at temperature and at room temperature after exposure. The strain rates used were 0.002 and 0.054 inches per inch per minute.

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